

HABITAT PROFILE

Shrublands

Federal Listing: Not listed

State Listing: Not listed

Associated Species: Golden-Winged Warbler (*Vermivora chrysoptera*), American Woodcock (*Scolopax minor*), New England Cottontail (*Sylvilagus transitionalis*), Smooth Green Snake (*Opheodrys vernalis*), Black Racer (*Coluber constrictor*), Wood Turtle (*Glyptemys insculpta*).

Global Rank: N/A

State Rank: N/A

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ELEMENT 1: DISTRIBUTION AND HABITAT

1.1 Habitat Description

Shrubland habitat (hereafter referred to as shrubland) refers to shrub-dominated areas with scattered forbs and grasses. These habitats are typically the result of some disturbance and include dry shrublands, utility rights-of-way, old agriculture fields, and reverting gravel pits.

1.2 Justification

Shrublands and other woody early-successional habitats are declining in New Hampshire and throughout the Northeast (Trani et al. 2001, Brooks 2003), as are the associated wildlife species (Hunter et al. 2001, Litvaitis 2001, Dettmers 2003, Wagner et al. 2003). For example, nearly half of the 33 shrubland birds covered by Breeding Bird Survey routes in the Northeast have significantly declined in the last 35 years (Dettmers 2003). Partners in Flight (PIF), a cooperative bird conservation organization seeking to maintain populations of North American land birds, has identified the Northeast as being particu-

larly important for maintaining source populations of shrubland birds (Dettmers 2003a, Dettmers 2003b). Since 1960, the distribution and abundance of New England cottontail has declined substantially throughout New England (Johnston 1972, Jackson 1973, Litvaitis 1993) and are being considered for listing under the federal Endangered Species Act (USFWS 2004). Additionally, 139 species of reptiles, amphibians, birds, and mammals either prefer (17 species) or utilize (122 species) shrub and old-field habitats (Scanlon 1992).

1.3 Protection and Regulatory Status

Shrubland habitats in general have no special regulatory status. Shrublands inhabited by state endangered or threatened species are protected under RSA 212 if habitat modification would affect the species.

Few natural resource protection programs focus on shrubland habitats.

1.4 Population and Habitat Distribution

It is difficult to determine the distribution of shrublands in New Hampshire because of limitations of remote sensing data (see section 1.8 for details). United States Forest Service's (USFS) Forest Inventory and Analysis (FIA) data indicate that from 1973 to 2002, the amount seedling/sapling forest declined 63% from nearly 449,000 hectares to just over 167,000 hectares. Seven counties experienced a 70 to 100% decline. Grafton County experienced a 55% decline. Coos County, where much of New Hampshire's industrial forests are located, experienced only a 12% decline .

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

Not completed for this habitat.

1.7 Sources of Information

Sources of information include journal articles, USFS FIA data, New Hampshire Landcover Assessment, 1998 aerial photos, and discussions with previous data users.

1.8 Extent and Quality of Data

Existing data sources are inadequate to map shrubland habitat to assess abundance and distribution in New Hampshire. FIA data include a series of nearly 400,000 field points on stand age, size, composition, ownership, etc. This information is useful in assessing wildlife habitat, assessing the sustainability of ecosystem management practices, and in making forest-planning decisions (USFS 2005). FIA data is more relevant to young forests than to shrubland habitats.

FIA plots classified as “non-stocked” (stocking of less than 10% of live trees) would ideally provide the best information on shrublands in New Hampshire (Frieswyk and Widman 2000). However, due to the sporadic and incomplete nature of data collection for this classification, the “non-stocked” classification was deemed unreliable (Carol Alerich, USFS-FIA program, personal communication). The next best indicator of the decline of shrubland habitats in New Hampshire is the trend in the amount of forestland dominated by seedlings and saplings (these stand size classes are typically lumped together in the FIA data). Data for seedling/sapling forest is not available for 1948 or 1963 (Carol Alerich, USFS-FIA program, personal communication).

Even if satellite imagery were more current, satellites are typically poor at detecting differences in vegetation structure (i.e., height and size of vegetation) (Bergen et al. 2002). Aerial photographs can be used, but would be time consuming and cost prohibitive if done for a large area (Dan Sundquist, SPNHF, personal communication).

1.9 Distribution Research

A better means of mapping shrubland habitats is needed to assess the abundance and distribution of New Hampshire’s shrublands. Two options are radar

and lidar sensors that can measure vegetation height and can directly estimate other variables related to vegetation structure (Bergen et al. 1997, Bergen and Dobson 1999).

ELEMENT 2: SPECIES/HABITAT CONDITION

2.1 Scale

Counties will be used as the conservation-planning unit for this habitat because that is the scale at which most information exists and because most technical and financial assistance (from the USDA NRCS, UNH Cooperative Extension, and others) is provided to private landowners by county.

2.2 Relative Health of Populations

Data on the distribution and health of shrublands are severely lacking (see section 1.8). From 1973 to 2002, the amount of area in seedling/sapling forest declined 63% from nearly 449,000 hectares to just over 167,000 hectares. Seven counties experienced a 70 – 100% decline. Grafton County experienced a 55% decline. Coos county, where much of New Hampshire’s industrial forests are located, experienced only a 12% decline.

It is difficult to ascertain the historic extent of shrublands in New Hampshire. Native Americans in coastal and inland river valleys used fire to create and maintain agricultural fields, improve hunting grounds, and maintain travel corridors, among other purposes (Day 1953, Harris 1972, Cronon 1983, Whitney 1994). Settlements often occurred on sandy, glacial outwash deposits of major river valleys where food was plentiful (Whitney 1994). Pitch pine-scrub oak barrens occur in these areas (Howard et al. 2005). The result of Native American burning was a mosaic of habitat types in different states of succession, likely including native scrub oak shrublands and heathlands.

Fire regimes may have greatly influenced vegetation patterns (Patterson and Sassaman 1988), though some researchers determined that the use of fire was location-specific and not as extensive as some suggest (Clark and Royall 1996, Parshall and Foster 2002). Parshall and Foster (2002) found that fires were more common over the last 300 years than in the preceding 1,500 years with a great portion of these fires occur-

ring during the early settlement period.

Historic accounts summarized in Askins (1997) indicate that beaver (*Castor canadensis*) activity also created open areas. After an abandoned beaver dam degrades and becomes breeched, the previously ponded area succeeds to a meadow dominated by sedges, grasses, and forbs and without further disturbance will succeed to shrubland. Beaver activity may influence 20-40 percent of the total length of second- to fifth-order streams (Naiman et al. 1988). One study in the Adirondack Mountains of New York found that beaver dams created patches of disturbance up to 12 ha in size (Remillard et al. 1987). Interestingly, an analysis of the current status of wet flats in New Hampshire (the flat floodplain area adjacent to streams and rivers that would be impacted by beavers) shows that nearly 30% (267 out of 961) of the wet flats 7 – 12 ha in size are impacted by agriculture and likely no longer serve as shrubland habitat. Another 17% (165 out of 961) are impacted by development (CSRC 2001, TNC 2003).

Weather-related disturbances such as wind and ice storms may infrequently create early-successional habitats. Hurricanes capable of causing extensive blowdown occur every 150 years on average in southeastern New Hampshire, every 380 years in central New Hampshire, and less than once every 380 years in northern New Hampshire (Boose et al. 2001). The January 1998 ice storm was a major weather event in New Hampshire's history causing significant damage to the forests of central and northern New Hampshire.

The amount of early-successional habitat increased dramatically after European settlement. Much land was cleared for farmland in the eighteenth and nineteenth centuries (Cronon 1983, Whitney 1994). However, cleared lands were abandoned in the mid-1800s for more productive farms in the Midwestern United States and the industrial cities of the Northeast. Many tracts of land that were cleared for agriculture reverted to second-growth forests and species associated with early-successional habitats abounded (Irland 1982, DeGraaf and Miller 1996, Foster et al. 2002, Litvaitis et al. 2005). Most of the abandoned farmlands matured into closed-canopy forests by 1960, causing shrubland species to decline (Litvaitis 1993). Today, given the lack of fires and the reduction in areas potentially impacted by beavers, coupled with effect of habitat fragmentation caused

by development, the future health of shrubland wildlife depends on active management.

2.3 Population Management Status

2.4 Relative Quality of Habitat Patches

It is difficult to assess the quality of habitat patches without a suitable habitat map. In general, habitat patch quality depends on a number of factors including vegetation structure (e.g., stem density), habitat patch size, and degree of habitat fragmentation in the surrounding landscape.

Vegetation Structure: Vegetation structure is a key component of shrubland habitats. Vegetation structure requirements can differ among wildlife species. For instance, New England cottontails require stem densities approaching 10,000 stems/hectare (Litvaitis and Tash 2005). American woodcock are found in areas with an overstory canopy cover of 53-64% in diurnal sites and a shrub canopy cover of 75-87% (Dunford and Owen 1973, Morgenweck 1977). The vegetation structure requirements are not clear for the other species covered under this profile.

Habitat Patch Size: Habitat patch size is also an important component to consider when evaluating habitat patch quality. Golden-winged warblers occupy patches that are at least 10 hectares in size (Confer 1992). Litvaitis (1993) found that New England cottontail occupied patches in southeastern New Hampshire ranging from 0.2 to > 15 ha, but very small patches were inherently volatile (Barbour and Litvaitis 1993, Villafuerte et al. 1997). Volatility of small patches is largely related to the relative abundance of generalist predators (e.g., coyotes, foxes, raccoons, skunks) within the surrounding landscape that, in turn, depends on the degree of habitat fragmentation expressed in the landscape (Barbour and Litvaitis 1993, Brown and Litvaitis 1995, Oehler and Litvaitis 1996).

Habitat Fragmentation: Southeastern New Hampshire is undergoing rapid development (Sundquist and Stevens 1999). Generalist predator populations in fragmented landscapes tend to increase because of the readily available food sources (e.g., trash, crops, pet food, etc.) (Oehler and Litvaitis 1996). As suit-

able habitat patches become increasingly smaller, wildlife species attempting to utilize those patches become increasingly vulnerable to predation (Brown and Litvaitis 1995). As such, shrubland patches in the southern part of the state should be at least 5 hectares in size if managing for New England cottontails and at least 10 hectares if managing for golden-winged warblers.

2.5 Habitat Patch Protection Status

Since habitat patches were not identifiable, no information on habitat patch protection status can be generated.

2.6 Habitat Management Status

Financial & Technical Assistance Programs

The USDA's Environmental Quality Incentive Program (EQIP) offers financial and technical help to agricultural producers to install or implement structural and management practices on eligible agricultural land (NRCS 2005b). An EQIP Technical Committee in each state sets eligible habitat improvement practices. There are nearly 70 eligible practices in New Hampshire. These include such things and nutrient management and the installation of manure storage facilities to restoration of declining habitats. Eligible EQIP practices that would benefit shrubland habitat include brush management, hedgerow planting, prescribed grazing, restoration and management of declining habitats, and tree/shrub establishment, among others (New Hampshire NRCS 2005a). Statistics are currently unavailable to determine how many hectares have been treated with each of these practices. In 2005, New Hampshire received nearly \$8 million for EQIP.

The USDA's Wildlife Habitat Incentives Program (WHIP) encourages the creation of high quality wildlife habitat on private land through technical and financial assistance (NRCS 2005c). Like EQIP, a WHIP Technical Committee in each state sets eligible habitat improvement practices. Like many states in the Northeast, New Hampshire's list of eligible practices include such things as brush management, early-successional habitat management/development, prescribed burning, tree/shrub planting, upland wildlife habitat management, and other practices appli-

cable to shrubland habitats (New Hampshire NRCS 2005b). Statistics are currently unavailable to determine how many hectares have been treated with each of these practices. In 2005, New Hampshire received over \$1,000,000 for WHIP.

Since 1990, the USFWS' Partners Program has provided technical and financial assistance to landowners, state agencies, organizations, and individuals to restore fish and wildlife habitat such as coastal wetlands, riparian habitats, and grasslands (USFWS 2001). Since its inception, the Partners Program has restored over 40.5 hectares of upland habitat in New Hampshire (USFWS 2001). It is unknown how many hectares specifically pertain to shrubland habitats.

NHFG administers the Small Grants Program, which was established to fund small-scale habitat restoration and enhancement projects on privately owned lands. Up to \$50,000 per year is committed to the Small Grants Program. The funds are obtained via a \$2.50 habitat fee required of all who purchase a New Hampshire hunting license. A number of Small Grant practices apply to shrubland habitats. These include release of apple trees, release of fruiting shrubs, mowing to maintain grasslands and shrublands, regeneration or restoration of alder or aspen/birch, and brush clearing/sapling removal to maintain old fields and shrublands. Since 2000, nearly 2,500 apple trees have been released, 14 hectares of fruiting shrubs have been released, 400 ha of grasslands or shrublands have been mowed, 20 ha have had alder or aspen/birch regenerated, and 438 ha of old fields have been maintained, (NHFG unpublished data).

UNH Cooperative Extension specialists and county-based educators in the Forestry and Wildlife Program also provide technical assistance to landowners on wildlife habitat management issues.

Management on State Lands

The NHFG owns in fee-simple or under conservation easement just over 334 ha of fields (NHFG unpublished data). Of these, 173 ha are maintained in active agriculture (either hay or cropland). The remainder is maintained by mowing occurring every 1-3 years after the bird nesting season. All of the fields under NHFG management should be evaluated to determine which ones would be more suited for shrubland habitat management rather than grassland management.

DRED owns in fee-simple or under conserva-

tion easement approximately 543 ha of fields and shrubland openings (DRED unpublished data). Forty hectares are maintained in active agriculture (either hay or cropland), 137 ha are maintained via mowing by State Parks or NHFG personnel, and the remainder is not maintained on a regular basis. The NHFG State Lands Biologist will be working with DRED to evaluate the fields under DRED management to determine which ones would be more suited for shrubland habitat management and to develop a management strategy.

Management on Other Lands

All other shrubland habitats occur on federal lands (e.g., WMNF, Umbagog National Wildlife Refuge, Great Bay National Wildlife Refuge, Pondicherry National Wildlife Refuge, and others), private land, and to a much lesser extent land of private land trusts, municipalities, and other conservation organizations/agencies. It is not known to what extent shrubland habitats are maintained on these lands.

2.7 Sources of Information

Sources of information for element 2 include journal articles, websites, GIS data, and white papers.

2.8 Extent and Quality of Data

It is difficult to assess the distribution and condition of shrublands without an adequate habitat map. The habitat requirements of some shrubland dependent wildlife are lacking.

2.9 Condition Assessment Research

- Determine specific habitat needs of shrubland dependent wildlife (e.g., vegetation structure and habitat patch size).
- Develop an adequate early-successional habitat map to identify and prioritize habitat management opportunities.

ELEMENT 3: SPECIES AND HABITAT THREAT ASSESSMENT

3.1.1 Altered Natural Disturbance (Natural Succession)

(A) Exposure Pathway

Shrubland-dependent vertebrate wildlife species require dense understory cover; their occurrence is influenced more by the height and density of vegetation than by specific plant communities (Litvaitis 2003). New England cottontail, woodcock, ruffed grouse, eastern towhee, and other shrubland species shift in space and time in response to natural succession, disturbance, and human land uses (Litvaitis 2005). As more open land is converted to development there is less overall space for shrubland-dependent species to shift into when natural forest succession or lack of active management makes their current habitat patch unsuitable.

(B) Evidence

Although over 80% of New Hampshire is reforested, second growth forests lack the structural diversity present in virgin forests. Forest maturation, coupled with suppression of natural disturbance (e.g., fire) has reduced the amount of early successional conditions (Litvaitis 2003). Concurrently, shrublands are being developed for residential and commercial purposes. Thus, early successional habitat is at or below historical levels (Brooks 2003). Human created shrublands (e.g., old fields, reverting gravel pits, rights-of-way) have increased in importance to shrubland-dependent wildlife. These human created shrublands tend to be ephemeral and require natural or human disturbance to retain their characteristics (Brooks 2003).

3.1.2 Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway

Direct loss of shrubland habitat occurs through the conversion of these lands for residential, industrial, and commercial purposes. Development patterns lead to fragmentation of remaining undeveloped habitats, creating smaller patches that may not sustain wildlife populations and promoting generalist predators that prey on shrub-dependent wildlife (Barbour and Litvaitis 1993, Litvaitis 2005).

(B) Evidence

In eastern North America over the last 60 years, open habitats (grasslands, savanna, barrens, and shrublands) have declined by 98%, with shrubland communities comprising 24% of this decline (Tefft 2005). New Hampshire's population grew by 17.2% from 1990 to 2004--the fastest growing state in the Northeast for the past four decades. New Hampshire has lost more than 17,000 acres of open space to development each year in the past five years (Society for the Protection of New Hampshire Forests, unpublished report).

The amount of shrubland habitat of functional quality for wildlife may now be falling below historic levels as current landscape conditions are strikingly different than in pre-settlement times (Brooks 2003). Habitat loss and fragmentation of remaining habitat is causing shrubland species to decline (Litvaitis 2005), especially New England cottontail, American woodcock, eastern towhee, golden-winged warbler, black racer, and smooth green snake since their populations are embedded in a rapidly developing landscape (Society for the Protection of New Hampshire Forests, unpublished report). Increases in generalist predators may reduce or even eliminate small populations of prey species like New England cottontails and some songbirds.

3.1.3 Recreation (Off Road Vehicles)**(A) Exposure Pathway**

Two and four wheeled all-terrain vehicles (ATVs) can have direct and indirect impacts on shrubland habitat and associated wildlife. Although by state law ATVs are not allowed on private land without permission or public roads, there is overwhelming anecdotal evidence of ATVs crossing lands without permission. Direct impacts include trampling vegetation by riding through and over shrubs. Indirect effects include the introduction of invasive species (carried inadvertently on the vehicle), excessive noise disturbance, and compaction and rutting of soil. These direct and indirect effects can degrade habitat quality for shrub dependent wildlife.

(B) Evidence

ATVs are registered through NHFG, which reported that ATV registrations doubled from 1998 to 2001 (from 9,452 to 18,001 ATVs). This increase follows a national trend with a concomitant increase in con-

cerns about negative impacts to soils, water, wildlife, and habitats. In April 2003, the USFS Chief Dale Bosworth identified unmanaged off-road vehicle use as one of the four greatest threats to the National Forests, along with fire, the spread of invasive species, and habitat fragmentation. Bosworth particularly noted the unplanned ATV tracks crisscrossing many forests. In New Hampshire, conflicts have arisen around ATV use at Pisgah State Park, Nash Stream, and on other public lands. Private landowners, including tree farmers, are raising concerns about detrimental effects by ATV riders on their lands. A report by the Montana Chapter of The Wildlife Society documents the direct and indirect effects of recreation, including off-highway vehicles, on wildlife and their habitats (Joslin and Youmanns 1999).

3.2 Sources of Information

Sources of information on threats to shrub-dominated early successional habitat included peer-reviewed scientific papers, GIS-analysis in reports by New Hampshire organizations, agricultural statistics from the USDA website, and gray literature.

3.3 Extent and Quality of Data

The decline in shrubland and other early successional habitats and their associated wildlife species is well documented. The effects of development that lead to fragmentation and the increase in generalist predators (e.g., coyote, fox, raccoon) are well documented. The impacts of ATV's on shrublands needs further study.

3.4 Threat Assessment Research

Studies are needed to determine the impacts of ATVs on wildlife and their habitats in New Hampshire.

ELEMENT 4: CONSERVATION ACTIONS**4.1.1 Habitat Conservation, Habitat Protection
Direct Threats: Development****(B) Justification**

The loss of open space in New Hampshire is a major threat to shrubland habitats. Permanently protecting shrublands that harbor species of concern (e.g., New England cottontail) through fee simple acquisitions

or conservation easements may be required to protect and manage species. Land conservation measures will provide an opportunity to manage ephemeral shrublands. Given the pace of development and loss of open space in New Hampshire, this conservation action should receive priority. Once lands are permanently protected the decision cannot be reversed, however management decisions to benefit priority wildlife species can be adapted to changing information and site conditions.

(C) Conservation Performance Objective

The conservation objective is to permanently protect, through fee simple acquisition or conservation easements, shrub-dominated early successional habitat that support populations of declining species including New England cottontail, American woodcock, and eastern towhee.

(D) Performance Monitoring

The measurable component is the acres of shrubland that support priority wildlife species that are permanently protected.

(E) Ecological Response Objective

The ecological objective is to ensure that populations of New England cottontails and other priority wildlife successfully reproduce in these permanently protected shrublands.

(F) Response Monitoring

Populations of New England cottontails and other key species in the protected shrublands should be monitored to determine their reproductive success and to determine if additional shrublands need permanent protection to sustain the populations statewide.

(G) Implementation

This conservation action requires the development of an adequate statewide habitat map to determine which shrublands are most significant for New England cottontail and other wildlife and that would benefit from permanent protection. This should include an assessment of which shrublands are best protected through fee simple acquisition and which shrublands can be adequately protected through conservation easements. The latter approach requires a conservation easement that incorporates the management strategies for maintaining shrubland conditions

such as mowing, cutting, prescribed fire, or grazing. These actions may be more easily incorporated into conservation easements for lands owned by conservation organizations rather than individual private landowners.

(H) Feasibility

The ephemeral nature of shrubland habitats makes it more difficult to identify priorities for permanent protection. The best approach may be to identify known areas of importance to New England cottontail, American woodcock, and other priority species and focus on conserving these core areas. Land conservation partners (e.g., land trusts) can be engaged to contact landowners with priority shrublands to assess their interest in selling their land or placing a conservation easement on their land. The Farmland Protection Program and North American Wetlands Conservation Act (NAWCA) may be more applicable for grassland conservation. The New Hampshire Land and Community Heritage Investment Program is a critical resource (if new funds become available). Permanent land conservation is typically more expensive than other conservation measures (such as encouraging shrubland management among private landowners).

4.1.2 Vegetation Management, Restoration, and Management

Direct Threat: Altered Natural Disturbance (Natural Succession)

(B) Justification

Since shrubland habitats are relatively short lived, periodic management is needed to maintain the dense habitat structure. Relatively stable shrublands require monitoring and selective removal of small trees that invade the area (e.g., every 5 years). Reclamation of old fields, pastures, or gravel pits that have succeeded to second growth forest will initially require aggressive clearing. Once shrublands become well established, they may require only periodic mowing or cutting, every 5 to 10 years or more (Tefft 2005).

Creating small patches of shrub-dominated early-successional habitats in New Hampshire's highly developed landscapes may not prove effective since predation pressure is often intense in small patches and surrounding land uses may create migration barriers.

Therefore, positioning managed habitats near existing patches of shrubland, wetland, or a beaver flowage would create larger patches of suitable habitat. The establishment and maintenance of some moderate (>10 acres) to large-size (>25 acres) patches of early-successional habitat can serve as core habitats within human-dominated landscapes (Litvaitis 2005).

Utility rights-of-way (e.g., power line corridors), offer another opportunity to create a larger mosaic of shrub-dominated early successional habitat. Recent research in southern New York has shown that power line corridors can be very productive habitat for a number of songbirds that nest in shrubby habitats. However, these linear habitats may not be suitable for other species affiliated with shrublands. New England cottontails, for example, are not found along corridors, possibly because raptors perched on utility poles are very efficient predators. Therefore, positioning several acres of managed early-successional habitat near a power line corridor could improve the suitability of corridors for cottontails and other species that may be vulnerable to predation. Placing managed habitats near utility corridors may also increase the ability of animals to move across a landscape by using the utility corridor as a dispersal route (Litvaitis 2005).

(C) Conservation Performance Objective

The conservation objective is to identify core areas of shrubland habitats in the state and apply vegetation management to maintain these habitats in a shrub-dominated early successional condition.

(D) Performance Monitoring

The measurable component is the number and acreage of core areas managed as shrub-dominated early successional habitat.

(E) Ecological Response Objective

The ecological objective is to increase the amount of functional shrub-dominated early successional habitat that supports reproducing populations of New England cottontails, woodcock, and other habitat associates.

(F) Response Monitoring

A suggested monitoring approach is to monitor the populations of key species (e.g., New England cottontail, American woodcock, eastern towhee) within the core shrubland habitats.

(G) Implementation

The core shrub-dominated early successional areas in the State need to be identified. If in public ownership, then land managers can manage the habitat. If core areas are on private lands, then an outreach program is needed to interest landowners in managing shrubland habitats. The NHFG Small Grants Program is important in reimbursing landowners for this type of management since there is typically no economic return from shrubland management. Relevant Farm Bill conservation programs should also take into consideration priority species and focus areas for shrubland habitat management. UNH Cooperative Extension and the NH Coverts Program have an extensive network of landowners interested in wildlife and could be valuable partners in identifying and maintaining core shrubland habitats as well as connectivity between habitat patches.

(H) Feasibility

NHFG can work with its state and federal partners to identify the most important shrub-dominated early successional habitats on state and federally owned lands. These shrubland habitats may be near extensive grassland habitats and could be managed collectively. Private landowners may be unwilling or unable (because of cost) to manage large shrubland areas so cost-share and grant programs are extremely important to achieving this conservation objective. The WHIP program and NHFG small grants program could support landowner involvement in managing shrubland habitats.

ATV Rider Education and Enforcement

Refer to the general recreation strategy.

4.2 Conservation Action Research

An important step in maintaining shrub-dominated early successional habitat is to identify the known core areas of this habitat type on public land. If public lands lack sufficient shrubland habitat to sustain the associated wildlife species of concern then analysis of private lands is needed to identify additional potential core areas. This includes an analysis of which lands may require permanent protection through fee simple or conservation easements assuming landowners are interested.

ELEMENT 5: REFERENCES

5.1 Literature

- Barbour, M.S., and J.A. Litvaitis. 1993. Niche dimensions of New England cottontails in relation to habitat patch size. *Oecologia* 95:321-327.
- Bergen, K.M., D.G. Brown, M.C. Dobson, and E. Gustafson. 2002. Integrating Radar Remote Sensing of Forested Habitat Structure: A Pilot Project for Biodiversity Informatics. Pages 149-154 in *Proceedings, National Science Foundation National Conference on Digital Government Research*, Los Angeles, California.
- Bergen, K.M. and M.C. Dobson. 1999. Integration of remotely sensed radar imagery in modeling and mapping of forest biomass and net primary production. *Ecological Modelling* 122: 257-274.
- Bergen, K.M., M.C. Dobson, L.E. Pierce. 1997. Effects of within-season dielectric variations on terrain classification using SIR-C/X-SAR. *Proceedings of the International Geoscience Remote Sensing Symposium*, Singapore, China.
- Brooks, R.T. 2003. Abundance, distribution, trends, and ownership patterns of early-successional forests in the northeastern United States. *Forest Ecology & Management* 185:65-74.
- Brown, A.L., and J.A. Litvaitis. 1995. Habitat features associated with predation of New England cottontails: what scale is appropriate? *Canadian Journal of Zoology* 73:1005-1011.
- Complex Systems Research Center. 2002. Landcover Assessment - 2001. University of New Hampshire, Durham. <http://www.granit.sr.unh.edu/data/datacat/pages/nhlc01.pdf>. Accessed 8 February 2002.
- Confer, J.C. 1992. Golden-winged warbler, *Vermivora chrysoptera*. Pp. 369-383 in K.J. Schneider and D.M. Pence, editors. *Migratory nongame birds of management concern in the Northeast*. U.S. Fish & Wildlife Service, Newton Corner, Massachusetts, USA.
- Cronan, W. 1983. *Changes in the land: Indians, colonists, and ecology of New England*. Hill and Wang, New York, New York.
- Day, G. 1953. The Indian as ecological factor in the northeastern forests. *Ecology* 34:329-346.
- DeGraaf, R.M., and R.I. Miller. 1996. The importance of disturbance and land-use history in New England: implications for forested landscapes and wildlife conservation. Pages 3-25 in R.M. DeGraaf and R.I. Miller, editors. *Conservation of faunal diversity in forested landscapes*. Chapman and Hall, London.
- Dettmers, R. 2003a. Status and conservation of shrubland birds in the northeastern US. *Forest Ecology & Management* 185:81-93.
- Dettmers, R. 2003b. DRAFT: Blueprint for the design and delivery of bird conservation in the Atlantic northern forest. U.S. Fish & Wildlife Service. 289pp.
- Dunford, R.D., and R.B. Owen, Jr. 1973. Summer behavior of immature radio-equipped woodcock in central Maine. *Journal of Wildlife Management* 37: 462-469.
- Foster, D.R., G. Motzkin, D. Bernardos, and J. Cardoza. 2002. Wildlife dynamics in the changing New England landscape. *Journal of Biogeography* 29:1337-1358
- Howard, L.F., J.A. Litvaitis, T.D. Lee, and M.J. Ducey. 2005. Reconciling the Effects of Historic Land Use and Disturbance on Conservation of Biodiversity in Managed Forests in the Northeastern United States: part 1—pine barrens. National Commission on Science for Sustainable Forestry. Washington, DC.
- Hunter, W.C., D.A. Buehler, R.A. Canterbury, J.L. Confer, and P.A. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. *Wildlife Society Bulletin* 29:440-455.
- Irland, L.C. 1982. *Wildlands and woodlots – a story of New England's forests*. University Press of New England, Hanover, New Hampshire, USA.
- Jackson, S.N. 1973. Distribution of cottontail rabbits (*Sylvilagus* spp.) in northern New England. M.S. Thesis, University of Connecticut, Storrs.
- Johnston, J.E. 1972. Identification and distribution of cottontail rabbits in southern New England. M.S. Thesis, University of Connecticut, Storrs.
- Joslin, G., and H. Youmans, coordinators. 1999. *Effects of recreation on Rocky Mountain wildlife: a review for Montana*. Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society.
- Kingsley, N.P. 1976. *The forest resources of New Hampshire*. U.S. Forest Service Resource Bulletin NE-43, Northeast Forest Experimental Station, Upper Darby, PA. 71 pp.

- Latham, R.E. 2003. Shrubland longevity and rare plant species in the northeastern United States. *Forest Ecology and Management* 185:21-39.
- Litvaitis, J.A., M.S. Barbour, A.L. Brown, A.I. Kovach, J.D. Oehler, B.L. Probert, D.F. Smith, J.P. Tash, R. Villafuerte, and M.K. Litvaitis. 2005a. Testing multiple hypotheses to identify the causes of the range-wide decline of New England cottontails. In review for forthcoming book, *Biology of lagomorphs - evolution, ecology and conservation*. P. Alves and K. Hackländer, editors.
- Litvaitis, J.A. 2001. Importance of early-successional habitats to mammals in eastern forests. *Wildlife Society Bulletin* 29:466-473.
- Litvaitis, J.A. 1993. Response of early successional vertebrates to historic changes in land use. *Conservation Biology* 7:866-873.
- Ludlum, D. 1976. *The Country Journal: New England weather book*. Houghton Mifflin: Boston, Massachusetts, USA.
- Miles, P.D. Dec-23-2004. Forest inventory mapmaker web-application version 1.7. U.S. Department of Agriculture, Forest Service, North Central Research Station, St. Paul, MN. [Available only on internet: www.ncrs2.fs.fed.us/4801/fiadb/index.htm]
- Morganweck, R.O. 1977. Diurnal high use areas of hatching-year female American woodcock. Pp. 155-160 in D.M. Keppie and R.B. Owen, Jr. editors. *Proceedings of Sixth Woodcock Symposium*, New Brunswick Department of Natural Resources, Fredericton, New Brunswick.
- Oehler, J.D., and J.A. Litvaitis. 1996. The role of spatial scale in understanding responses by medium-sized carnivores to forest fragmentation. *Canadian Journal of Zoology* 74: 2070-2079.
- Patterson, W.A. III, and K.E. Sassaman. 1988. Indian fires in the prehistory of New England. Pages 107-135 in G.P. Nichols, editor. *Holocene human ecology in northeastern North America*. Plenum Publishing Corporation, New York, New York.
- Scanlon, J.J. 1992. Managing forests to enhance wildlife diversity in Massachusetts. *Northeast Wildlife* Vol. 42.
- Sundquist, D., and M. Stevens. 1999. *New Hampshire's changing landscape: population growth, land conversion and resource fragmentation in the Granite State*. The Society for Protection of New Hampshire Forests, Concord, New Hampshire, USA.
- Tefft, B.C. 2005 (in prep.) Shrublands and old fields. *In A guide to managing grasslands, shrublands, and young forest habitats in the northeast*. Oehler, J.D. and D.F. Covell, eds. Northeast Upland Habitat Technical Committee and Massachusetts Division of Fisheries & Wildlife.
- The Nature Conservancy. 2003. Ecological landunit data layer. Conservation Science Support Program, Eastern Resource Office of The Nature Conservancy, Boston, Massachusetts.
- Trani, M.K., R.T. Brooks, T.L. Schmitt, V.A. Rudis, and C.M. Gabbard. 2001. Patterns and trends or early-successional forests in the eastern United States. *Wildlife Society Bulletin* 29:413-424.
- United State Fish & Wildlife Service. 2004. Endangered and threatened wildlife and plants; 90-day finding on a petition to list the New England cottontail as threatened or endangered. *Federal Register* 69: 39395-39400. <http://www.epa.gov/fedrgstr/EPA-SPECIES/2004/June/Day-30/e14610.htm>.
- United States Forest Service. 2005. Program structure for forest inventory and monitoring: FIA fact sheet series. United States Department of Agriculture. 2pp. http://fia.fs.fed.us/library/fact-sheets/overview/Pgm_Structure_FS.pdf.
- Villafuerte R., J.A. Litvaitis, and D.F. Smith. 1997. Physiological responses by lagomorphs to resource limitations imposed by habitat fragmentation: implications to condition-sensitive predation. *Canadian Journal of Zoology* 75:148-151.
- Wagner, D.L., M.W. Nelson, and D.F. Schweitzer. 2003. Shrubland lepidoptera of southern New England and southeastern New York: ecology, conservation, and management. *Forest Ecology & Management* 185:95-112.
- Whitney, G. 1994. *From coastal wilderness to fruited plain: a history of environmental change in temperate North America from 1500 to present*. Cambridge University Press, Cambridge, Massachusetts.
- Zielinski, G.A. 1998. Extreme Climatic Events in New England History. In *New England's changing climate, weather, and air quality*. Climate Change Research Center, University of New Hampshire. <http://www.neci.sr.unh.edu/necccaq.html#5>